JOURNAL OF SCIENCE AND APPLIED ENGINEERING (JSAE), *May 2018, Vol 1(1), 10-19*
E-ISSN: 2621-3753
P-ISSN: 2621-3745

Analysis Of Biodiversity And Quality Of Metro River In Malang City (Plankton and Bentos Bioindicator Study)

H. Setyobudiarso[1], E. Yuwonoi[2]
[1] Environmental Engineering Study Program of National Technology Institute of Malang
[2] Civil Engineering Study Program National Institute of Technology Malang
Email : hery_sba@yahoo.com

ABSTRACT

Metro River is a river that passes through Malang City and empties into Karangkates Dam. The increasing number of residents of Malang City resulted in more volume of waste water produced, and one of them is dumped on the Metro River. This affects the increasing pollution load received by the river so that it affects the decreasing of tamping capacity of river pollution load. Changes in water quality in rivers lead to changes in macrozoobenthic community composition. Therefore, it is necessary to monitor the quality status of Metro River by using macrozoobentos animals. The purpose of this research is to make the classification of Metro River based on macrozoobentos animal community in determining the water quality status of Metro River based on macrozoobentos and the classification of pollution level that happened. The research method is field observation, water quality measurement of Metro river and macrozoobentos sampling. The results showed that the distribution of macroinvetebrata in the Site of group of Banana Temple was from Gastropoda family, Leptophlebiidae, Chloroperliidae, and Baetidae on rocks with fast current velocity (1.02 m3 / s), 17-27 ° C, BOD level 3.7 mg / l, and COD content of 20.8 mg / l. While on the Site of group Merjosari, Karang Besuki, Bandulan and Sitirejo were found macrozoobentos from Chironomidae, Hydrop sychidae and Lumbri cullidae families, on the substrate of mud and sand, with slow flow rate (0.0052 - 0.0675 m3 / s), BOD 21, 8 - 45.7 mg / l, and COD content 107.8 -267.2 mg / l. The status of upper Brantas river waters determined by using the BMWP Index of the Pisang Candi, Merjosari, Karang Besuki, Bandulan and Sitirejo groups has medium gray water status with ASPT values ranging from 4 to 6.2..

Keywords *macrozoobentos, Water Quality Status of River, BOD, COD*
Paper type Research paper

INTRODUCTION

River water plays a strategic role in supporting other living creatures with dynamic properties, then in its utilization can potentially reduce the value of the river's own benefits and impact on environmental conditions. The dynamics of river water environment condition which consist of abiotic and biotic components always interact with each other through energy flow and nutrient cycle and when interaction of both is disturbed there will be an imbalance in the aquatic ecosystem [9,19].

Aquatic macroinvertebrates can provide clues to the presence of pollutants entering the waters, as certain species are highly sensitive to contamination. Marine macroinvertebrates in general can not be used as a hint of the type of pollutant but it can be done chemistry laboratory testing.

Many types of macroinvertebrates such as beetle larvae (Coleoptera), nymphs dragonflies (Odonata), snails, slugs and shrimps have moderate sensitivity to contaminants. Thus if there is a certain type of macroinvertebrata in the waters there is an indication that the waters have been no pollutants. Another type of macroinvertebrate types of hair worms and leeches belonging to species that are not sensitive to pollutants and still able to survive in waters that have been polluted or poor quality. It is said by Subekti [23] that if the waters have found hair and leech worms, it means the waters are very polluted.

In the effort to estimate water quality, besides done by physics-chemical method which is quite complex, also needed method of bioiogi especially to control contaminant which is toxic. Benthic macroinvertebrate communities are considered appropriate for biota indicator of river waters by living in the bottom waters and having high diversity. From the actual change in benthic macroinvertebrate community structure, depots serve as the basis for information on levels of synthetic detergent. If this can be ascertained then the object of assessment of pollution level of synthetic detergent can be based on the change of benthic macroinvertebrate community structure

In a river basin system, the river that serves as a water drainage container is always in the lowest position in the earth's landscape, so that the river condition can not be separated from the condition of Watershed [1]. The quality of river water is influenced by the quality of the water supply coming from the catchment area while the quality of the water supply from the catchment area is related to the human activity in it [28]. Changes in water quality conditions in river flows are the impact of discharges from existing land uses [24]. According to Nontji [16] the river is a flowing open water (lotik) which gets input from all the discharges of various human activities in residential, agricultural, and industrial areas in the surrounding area. Discharge into the river will result in changes in physical, chemical, and biological factors in the water. This change can deplete the essential ingredients in the waters so as to disturb the aquatic environment. The development of Brantas River Basin (DAS) activities, such as increasing population settlements, household industry activities, and agricultural activities, can affect the quality of the water, since the waste generated from the activities of the population is discharged directly into the river. , and intensification of irrigation water will cause various problems.

Explains that the biotic component can provide an overview of the physical, chemical, and biological conditions of a water [17]. One biota that can be used as a biological parameter in determining the condition of a water is a macrobentos animal. As a living organism in the waters, macrobenthic animals are very sensitive to changes in the quality of the water in which they live, which will affect their composition and abundance. In the Brantas Basin the upstream part of the main pollution source comes from domestic waste (household and agriculture / natural). The input of organic matter into the water has a very complex effect, not only deoxygenation in water, but it can occur addition of suspended solids, toxic materials such as ammonia, sulfide or cyanide and the effect on the composition and abundance of the biological community in this case are macrobentos.

Changes in land use patterns to agricultural land, moor and settlements and increased industrial activity will have an impact on hydrological conditions within a watershed. In addition, various human activities in meeting the needs of their life derived from industrial activities, households, and agriculture will produce waste that contributes to the deterioration of river water quality [24]. According to Priyambada [20] that land-use changes marked by increased domestic, agricultural and industrial activities will affect and impact on river water quality conditions, especially domestic activities that provide the largest input of BOD concentration to river bodies. Macrozoobenths are present throughout the river from upstream to downstream. With the existence of a living macrobentos with a relatively long time, then this macrobentos can be used to predict the status of a water. The use of macrobentos as water quality estimator can be used for pollution estimation both from point source pollution and diffuse source pollution.

Instruments, Laboratory Methods and Monitoring Parameters River water quality analysis is a water testing process according to the parameters has been determined in the laboratory, using the specified test method for each parameter. Selection of measurement parameters depends on the designation of water bodies (ecosystem, drinking water, recreation, industry, agriculture) and the purpose of the study. According to Organisms that include macroinvertebrates are phylum Porifera, Cnidaria, Platyhelminthes, Nemertea, Nematodes, Nematomorpha, Annelida, Mollusca, Arthropoda [11]. Plankton (phyto-zoo) plays an important role in affecting the primary productivity of river waters. In addition to plankton, benthic organisms can also be used as biological indicators in studying river ecosystems. This is due to the different responses to a pollutant entering the river waters and being immobile [11,12]. Rosenberg [2] states that some plankton organisms are tolerant and have different responses to changes in water quality. One approach is to use the saprobic index, which is used to determine the degree of dependence or the relationship of an organism to the compounds that are the source of the nutrients. So it can be seen the relationship of plankton abundance with the level of pollution of a waters [6].

Environmental change can be a decline in diversity, physiological changes, and behavioral changes [18]. The presence of waste into the river, such as organic waste (feces, animal waste, fish feed, and foliage) and inorganic (pesticides and lubricating oil from tractors) are foreign objects for organisms in the river. Every organism has a limit of tolerance to a factor that exists in its environment [22]. Biological indicators are an easy guide to monitor the occurrence of contamination. The existence of environmental pollution resulted in the diversity of species will decrease and the food chain becomes simple, except when fertility occurs [22]. The ideal species used as biological indicators for the aquatic environment fall within groups of organisms that have no vertebrae or can be called macro invertebrates. According to [22] organisms that can be used as indicators of river pollution biology must meet the following criteria: 1) Easy to identify; 2) Easy to sample; 3) The distribution is cosmopolitan; 4) Easy stockpiling of pollutants; 5) Easy to cultivate in the laboratory; 6) Having a small variety of species; 7) Have sensitivity to environmental change. Environmental change can be a decline in diversity, physiological changes, and behavioral changes [18]. The presence of waste into the river, such as organic waste (feces, animal waste, fish feed, and foliage) and inorganic (pesticides and lubricating oil from tractors) are foreign objects for organisms in the river. Every organism has a limit of tolerance to a factor that exists in its environment [22].

Biological indicators are an easy guide to monitor the occurrence of contamination. The existence of environmental pollution resulted in the diversity of species will decrease and the food chain becomes simple, except

when fertility occurs [22]. The ideal species used as biological indicators for the aquatic environment fall within groups of organisms that have no vertebrae or can be called macro invertebrates. According to [22] organisms that can be used as indicators of river pollution biology must meet the following criteria: 1) Easy to identify; 2) Easy to sample; 3) The distribution is cosmopolitan; 4) Easy stockpiling of pollutants; 5) Easy to cultivate in the laboratory; 6) Having a small variety of species; 7) Have sensitivity to environmental change.

METHOD

Place and time of research

This research was conducted on upstream river flow upstream downstream. Sampling is done 5 times at intervals once a month, from March to April 2017 Sampling and water quality measurements Sampling of macrozoobenthos for hard substrate regions using benthic nets of size (20 x 30 cm, mesh size of 0.5 mm) and for soft substrate areas using Ekman Grab (15 x 15 x 20 cm). The steps are as follows: (1) macrozoobentos samples taken by using bentos nets or Ekman Grab, inserted in plastic containers and preserved in 70% alcohol, (2) bringing to the laboratory, separated between impurities and macrozoobentos and then identified to the family level, if possible to the genus or species level.

No	Parameter	Unit	Method	Place
1.	Suspended solids	mg/l	Gravimetri	Laboratory
2.	Dissolved oxygen (DO)	mg/l	Titrimetrik	Field
3.	BOD5	mg/l	Titrimetrik	Laboratory
4.	COD	mg/l	Titrimetrik	Laboratory

Analysis of Macrobentos data

Twinspan

To obtain the classification of the data obtained was analyzed by using the stratified classification, ie by using a program a computer called Two-way Indicator Species Analysis (TWINSPAN BMWP IndexThe data obtained are then analyzed to obtain the status of the waters by using the BMWP Index. The steps:

1. the classified data is matched to the BMWP table and scores on each family per station
2. from score obtained every macrozoobentos family, then look for the value of Average Score Per Taxon (ASPT) it. This ASPT value determines the water quality status.

$$\text{Nilai ASPT} = \frac{A}{B} \quad (1)$$

Information :

A: total score index BMWP

B: number of families found and score

- ASPT value: 1-4 for heavy gross waters
- ASPT value: 5-7 for cotacted waters
- ASPT value: 8-10 for clean water.

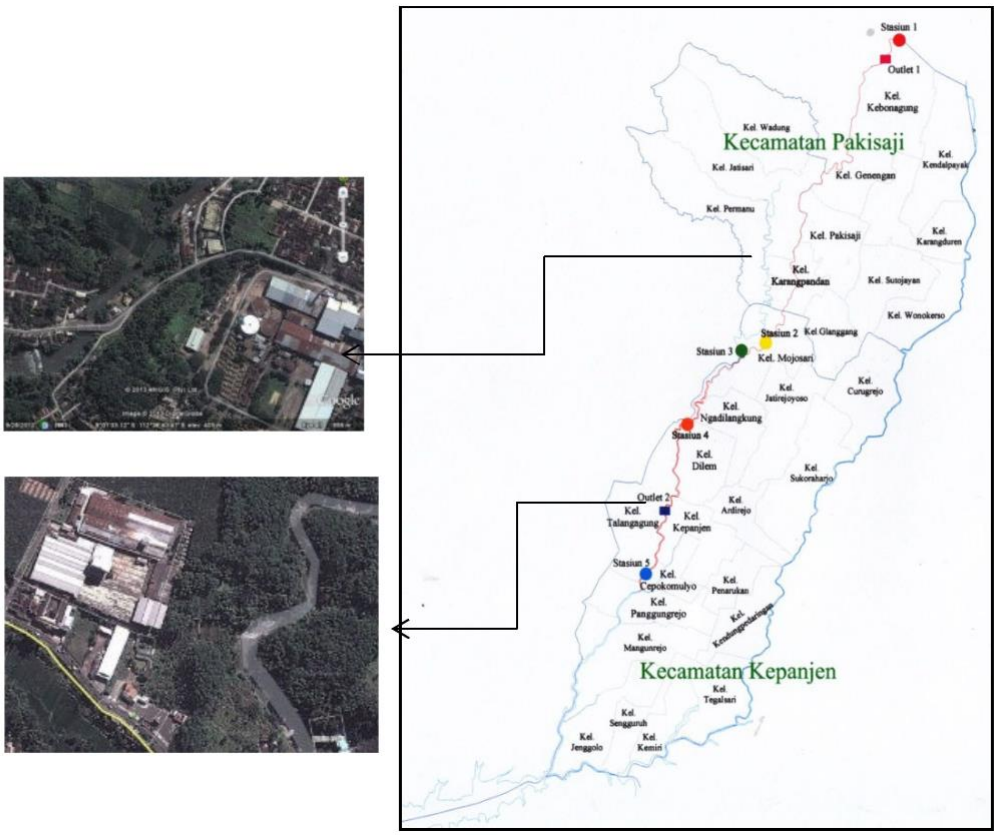

Fig. 1. Point Sources Scheme of Metro River

Here is the location of the sampling as shown in Figure 3.1, the sampling point is divided into several stations and outlets in this study are:

- Station 1 (ST1)

Station 1 is the upstream area of the Metro River and before the industrial sewerage outlet.

- Outlet (OT1)

Outlet 1 is the industry's IPAL outlet point. Taken to know the characteristics of wastewater before entering the Metro River body.

- Station 2 (ST2)

Station 2 is the water sampling point of the river after the industrial IPAL outlet.

Around the river there are settlements, agriculture and lots of green vegetation.

- Station 3 (ST3)

Station 3 is the water sampling point of the river after the Metro River. Around the river there are settlements and many overgrown with green vegetation dominated by bamboo trees.

- Station 4 (ST4)

Station 4 is the point of sampling of river water before the outlet of the industrial wastewater ducts. Around the river is overgrown with green vegetation dominated by bamboo trees.

- Outlet 2 (OT2)

Outlet 2 is an industrial sewerage outlet point. Taken to know the characteristics of wastewater before entering the Metro River body.

- Station 5 (ST5)

Station 5 is located in Kelurahan Cempokomulyo Kec Kepanjen. This is a downstream area of the Metro River. The aim is to know the quality of river water as a whole so that the test result data in the downstream area can be compared with the data for the upstream area.

Particularly for the confluence of two rivers or the inclusion of creeks, the location of the sampling is where the second area of water has been completely mixed.

Measurement of Water Debit, Water Sampling and Water Sampling

a. Measurement of River Water Debit

The method used in the measurement of river water discharge is cross section method (river profile). With this method the river water discharge can be obtained from the multiplication between the cross-sectional area of the river and the speed of the river water flow.

The calculation of the discharge using the following formula:

$$Q = v \times A \quad (2)$$

Description :

Q : Water discharge (m^3 / sec)
v : Current velocity (m / sec)
A : Cross-sectional area of the river (m^2) [25]

b. Water Sampling

Water sampling at industrial sewer outlets and river water samples is collected by grab sampling and According to Effendi, a momentary sample or grab sample is a sample taken directly from the water body being monitored.

River Metro river sampling steps with the following steps:

1. Preparation of sampling equipment.
2. Implementation of Water Sampling.

c. Preservation of Water Samples

After sampling the water at each station, it is important to maintain its integrity and ensure it is not contaminated, or prevent any changes before being analyzed in the laboratory. Sampling preservation is intended to avoid physical and chemical changes

Analysis Method

Industrial Waste Water Pollution Analysis

The industrial waste water pollution load can be calculated by the following formula:

1. Maximum Pollution Expense

$$BPM = (CM)j \times Vm \quad (3)$$

Description :

BPM: Maximum pollution load per product unit (kg / ton)

(CM) j: The maximum content of pollutant j (mg / l)
Vm: Maximum liquid waste volume (m^3 / ton)

2. Beban Pencemaran sebenarnya

$$BPA = (CA)j \times Va \quad (4)$$

Description :

CPA: The actual pollution load (kg / ton)
(CA) j: The actual content of pollutant element j (mg / l)
Va: The actual volume of wastewater (m^3 / ton)

Calculation of pollution load can be as control to industries, whether the industry is treating the waste well or not, and according to the provision of BPA can not be greater than BPM.

DISCUSSION

Water Quality Condition of Metro River

Water quality includes the properties of water and the content of living things, substances, energy or other components present in water. Water quality is performed to determine the suitability of water for a certain designation, compared to the water quality standard according to the water class.

From the monitoring result conducted by Perum Jasa Tirta in 2001, the result of water quality testing for BOD and COD parameters at each monitoring station at metro bridge location, as follows:

Table 1. Quality of River Water in Metro Region Laboratory Monitoring Results PJT-I Year 2012

No	Location	Date	BOD (mg/l)		COD (mg/l)		TSS (mg/l)	
			BM*)	result	BM*)	result	BM*)	result
1	Jemb Metro	3-Jan	3	5.05	25	11.3	50	106.6
2	Jemb Metro	1-Feb	3	2.5	25	5.933	50	209.5
3	Jemb Metro	1-Mar	3	5.1	25	12.96	50	81.5
4	Jemb Metro	2-Apr	3	6.9	25	14.26	50	101.3
5	Jemb Metro	3-May	3	3.3	25	8.429	50	43.6
6	Jemb Metro	4-Jun	3	3.2	25	10.32	50	22.2
7	Jemb Metro	3-Jul	3	4.25	25	9.545	50	30
8	Jemb Metro	1-Aug	3	6.1	25	14.25	50	14.5
9	Jemb Metro	3-Sep	3	7	25	18.63	50	20.3
10	Jemb Metro	1-Oct	3	4.6	25	10.91	50	18
11	Jemb Metro	1-Nov	3	5.8	25	13.7	50	52.3
12	Jemb Metro	3-Dec	3	7.85	25	17.43	50	9.1

*Source: Secondary Data, 2012 *) Standard of Quality Standard of Regulation 2/2008 class II*

POINT	BOD	DEBIT	POINT	BOD	DEBIT
1	3.66	0.687	11	4.19	2.962
2	4.25	1.433	12	4.35	3.448
3	3.39	1.415	13	5.35	3.973
4	4.89	1.556	14	4.88	4.383
5	3.82	1.815	15	4.21	4.393
6	3.98	1.607	16	3.60	4.127
7	5.32	1.578	17	3.2	4.942
8	3.39	1.957	18	3.25	4.837
9	3.71	2.431	19	3.34	7.844
10	3.87	2.675			

Table 2. Test Result Analysis of Water Body Samples
In Malang Regency Year 2012

No	Parameter	Unit	Result	quality standards *)	Information
	Kali Metro (Pakisaji)				
1	Temperature	^{0}C	25,0	Deviasi 3	Natural Condition
2	pH		7,9	6 – 9	Meet
3	BOD	mg/l	5,35	3	Exceeded
4	COD	mg/l	11,91	25	Meet
5	TSS	mg/l	14,2	50	Meet
	Metro (Kepanjen)				
1	Temperature	0_C	24,1	Deviasi 3	Natural Condition
2	pH		8,2	6 – 9	Meet
3	BOD	mg/l	3,20	3	Exceeded
4	COD	mg/l	9,768	25	Meet
5	TSS	mg/l	23,1	50	Meet

*Source: Secondary Data, 2012 *) Standard of Quality Standard of Regulation 2/2008 class II*

TURBIDITY (NTU)	TURBIDITY (MG/L)	pH	Temperature (C)
0.5	1.175	7.6	26
0.4	0.94	7.7	26
0.5	1.175	7.6	26
0.6	1.41	7.8	26
0.8	1.88	7.7	26
1.1	2.585	7.6	26
1.6	3.76	7	26
1.8	4.23	6.7	26
1.1	2.585	7.5	26

From the monitoring result of BLH of Malang Regency showed that on Metro River at Kali Metro location (Pakisaji sub district) and at Metro Bridge location (Kepanjen sub district) for BOD parameter has exceeded the quality standard set in Local Regulation Number 2 Year 2008 class II.

Water quality includes the properties of water and the content of living things, substances, energy or other components present in water. Water quality is carried out to determine the suitability of water for a certain designation, compared with the water quality standard according to the water class.

The parameters used to describe the water quality of Metro River are BOD and COD. This parameter is taken because it can give an idea of the natural ability of river in degradation of organic material in it. Water sampling to be analyzed was done on the date of 06.00 - 08.00 wib and done three (3) times of repetition analysis. The results of river water quality analysis with BOD and COD parameters as shown in Figure 4.3

Table 3 Water Quality of Metro River

No.	Segment	BOD (mg/l)	COD (mg/l)
1.	Segment 1	4,5	25,6
2.	Segment 2	4	23,5
3.	Segment 3	3,7	20,8
4.	Segment 4	3,6	19,2
5.	Segment 5	2,15	11,5

Source: Analysis Result

The content of COD, only in segment 1 has passed the class II standard, which is 25 mg / l, while for segments 2, 3, 4, and 5 are still below the class II water quality and tend to increase every year considering domestic activities in the region Metro River border is increasing. This is due to the increasing number of residents in the city of Malang, resulting in the volume of wastewater discharged also increases

Pollution Source Debit Pollution Source

The source of pollutants analyzed is a source of pollutants that directly into the river water body Metro. The source of pollutants entering the water body is a source of pollution from domestic waste, this is because the river border is a residential area of the citizen. This domestic waste flows through the drainage channel of settlements that empties into the Metro River. As for the discharge on each pollution source is as follows:

Table 4 Discharge of Pollutants and River Resources

No.	Locate	Debit (m^3/s)	Information
1.	Merjosari	0.0064	Point Source
2.	Karang Besuki	0.0675	Point Source
3.	Pisang Candi	1.02	river
4.	Bandulan	0.0086	Point Source
5.	Sitirejo	0.0052	Point Source

Source: Analysis Result

The above debit is still relatively small. However, the source of pollutants above flows continuously every day, although with different amount of discharge. Under such conditions the above wastewater may contribute to the contamination of the Metro River if all the source points entering the Metro River are accumulated.

Water Quality of Pollutant Source

After knowing the discharge from each pollutant source, then is analyzing the concentration of BOD and COD used as parameter in the pollutant source. In table 4.5 below presented the data of the concentration of waste water and creeks entering the Metro River.

Table 5. Concentration of pollutant sources and river

No.	location	consentrate (mg/l)		Type	Information
		BOD	COD		
1.	Merjosari	45,7	267,2	Point Source	Domestic
2.	Karang Besuki	20,8	129,6	Point Source	Domestic
3.	Pisang Candi	4,1	20,80	river	-
4.	Bandulan	32,3	161,6	Point Source	Domestic
5.	Sitirejo	21,8	107,8	Point Source	Domestic

Sumber : Hasil Analisa

Based on the above table, it can be seen that the pollutant concentration is still below the wastewater quality standard of 100 mg / l for BOD in accordance with the Decree of the Minister of Environment no. 112/2003 on the

Quality Standard of Domestic Wastewater. For COD parameters in domestic waste, the government has not set how much the quality standard for COD.

Biodiversity and Adaptation

The number of individual macrozoobenthos found on four stations on the Metro river during the observation took as many as 1,247 individuals who were covered in 7 classes overall. The most dominant classes were Gastropoda of 62.67%, Bivalves at 24.00%, Crustacea 6.67%, Holothuroidea 2.67%, Echinoidea, Asteroidea and Ophiuroidea respectively 1.33%. The large number of species of the Gastropoda and Bivalvia class found in the waters of the Metro river relate to the ability of the species to adapt to the tidal environment. Nybakken states that some classes of gastropods have operculum that can seal the crevice gap, when the water recedes into the shell and seal the operculum so that the lack of water can be overcome. Furthermore, Whitten) states that the high abundance of Gastropoda because the class has a waterproof skin and serves as a barrier, can climb trees to get food.

Bivalve class is almost the same as Gastropoda, some bivalves can live on the Metro river at the study site because it has the ability to seal its valve to prevent water loss at low tide. Some of these species can be attached to trees to get food such as Saccostrea echinata and Saccostrea cucullatta found in relatively larger numbers of individuals.

Crustacean classes are less able to adapt to extreme environments, and can move quickly when they are captured causing fewer species found in the class than the number of Gastropoda and Bivalvia species. Only Pagurus bernhardus can be found alive and shelter in other benthic shells and Balanus amaryllis whose shells attach to the roots of trees, is a species of the crustacean class that is more easily captured when macrozoobenthic sampling is performed.

Macrozoobentos are found from the order of Pulmonata is Limnaeidae. Gastropods are organisms that have a wide spread range in rocky, sandy, or muddy substrates, but these organisms tend to favor sandy substrates. The current velocity is slow (0.25 m / s) and has a sand bottom substrate and is slightly muddy.

On the station there are many densely populated settlements and domestic wastes dumped directly into the river. The presence of waste that inhibits the flow of the stream causes the flow to be slow and the low quality of water is found to be found Chironomous sp and Tubifex sp, because according to Wilhm [27], organisms Chironomous sp and Tubifex sp is a tolerant group, where the organism of this group in general will not feel the environmental pressure and the enrichment of organic matter.

Lack of number of species from the Echinoidea, Asteroide and Ophiuroidea classes found in the study sites because in general the species of the Echinoidea class, Asteroide and Ophiuroidea favor the sandy substrate (visual substrate observation), in order to immerse themselves. The sandy substrate at the study site is the type of substrate that is less favored by many species of the class.

Stasiun	Macrozoobentos Parameters				
	Number of Species	Abundance (ind./m2)	Diversity (H')	Dominance (D)	Uniformity (E)
I	44	51,89	1,43	0,05	0,87
II	31	27,56	1,11	0,12	0,74
III	53	55,11	1,47	0,05	0,89
IV	68	78,44	1,67	0,02	0,90

Status of river waters upstream

Based on the value of the BMWP Index and ASPT value calculation, then in this study got the range of ASPT numbers between 4 - 6.1 which means that the condition of these waters are in the status of medium gross waters up to gross weight. When viewed from the value of its ASPT, the status of medium dirty water which generally can be utilized for the purposes of agriculture, livestock and fishery and still meets the standard criteria of water body quality standard

CONCLUSION

1. The distribution of macroinvetebrata is limited by the type of substrate, ie the group that lives in the area of eroding substrata (rock, gravel, sand) and the group living in substrata depositing area (mud). The site of group of Banana Temple found macrozoobentos among others from the family of Gastropoda, Leptophlebiidae, Chloroperliidae, and Baetidae, which have habitat on gravel base and rocks with fast current velocity (1.02 m3 / s), 17-27 ° C, BOD concentration of 3.7 mg / l, and COD content of 20.8 mg / l. While on the Site of group Merjosari, Karang Besuki, Bandulan and Sitirejo were found macrozoobentos from Chironomidae, Hydrop sychidae and Lumbri cullidae families, which correspond to the substrate of mud and sand bottom substrate, with slow flow rate (0.0052 - 0.0675 m3 / s), BOD content 21.8 - 45.7 mg / l, and the content of COD 107.8 -267.2 mg / l.
2. The status of upper Brantas river waters determined by using the BMWP Index in this study are as follows: - Site of group Pisang Candi, Merjosari, Karang Besuki, Bandulan and Sitirejo have medium dirty water status with ASPT values ranging from 4 to 6 , 2.

ACKNOWLEDGMENT

-

REFERENCES

[1] Anonym. 2011. Peraturan Pemerintah Republik Indonesia Nomor 38 Tahun 2011 Tentang Sungai. http://hukum.unsrat.ac.id/pp/pp2011_38.pdf. Diakses Kamis, 31 Januari 2013.

[2] Ardi. 2002. Pemanfaatan Makrozoobentos Sebagai Indikator Kualitas Perairan Pesisir. Tesis PS IPB. Bogor.

[3] Arsyad Sitanala, (2010). Konservasi Tanah dan Air. Edisi Kedua, IPB Press. Bogor

[4] Boyd, C.E. dan F. Lichtkoppler. 1982. Water Quality Management In Pond FishCulture. Auburn University. Alabama

[5] Cummin. K.W. 1975. Macro Invertertebrate. In.Witton.B.A (Ed). Rivers Ecology. Blackwell Scientific. London

[6] Dahuri. R. 1995. Metode dan Pengukuran Kualitas Air Aspek Biologi. IPB. Bogor

[7] Davis, B.R. 1976. The Dispersal of Chironomidae a River. Journal of Entomological Society South Africa. p:39 – 62.

[8] Edmodson. 1983. Fresh Water Biology. John Willey and Sons. New York

[9] Ferianita, M, Fachrul, Herman, H, Listari, C. 2008. Komunitas Fitoplankton Sebagai Bioindikator Kualitas Perairan Teluk Jakarta. Jakarta: Universitas Trisakti.

[10] Hawkes.,H.A. 1978. Invertebrates as Indicators of Rivers Water Quality. In. A. James and L. Evison (Ed) Biological Indicator of Water Quality. John Willey & Sons.Toronto

[11] Hawking, J.H. dan Smith, F.J. 1997. Colour Guide To Invertebrates of Australian Inland Waters. Albury : Co-operative Research Centre for Freshwater Ecology

[12] Hilsenhoff,W.L. 1977. Use of Arthropods to Evaluate Water Quality Strem. JohnWilley & Sons. Toronto

[13] Hutabarat. H. Evans. 1986. Kunci Identifikasi Plankton. PT.Yasa Guna. Jakarta.

[14] Hynes, H.B.N. 1972. The Ecology of Runing Water. Liverpool University Press. England

[15] Kovacs, M. 1992. Biological Indicators of Environment Protection. Ellis Horwoad. New York

[16] Nontji, Anugerah. (1986). Laut Nusantara. Jakarta: Penerbit Djambatan.

[17] Odum, E.P. 1971. Fundamentals of Ecology. W.B. Sounders. Philadelpia

[18] Oktavia, Z. 2000. Pengukuran Kualitas Air Aliran Ranu Klakah di Kecamatan Klakah Kabupaten Lumajang Berdasarkan Indikator Biologi(MakroInvertebrata). Skripsi. Malang: Fakultas Keguruan dan Ilmu Pendidikan. Universitas Negeri Malang. (tidak dipublikasikan).

[19] Pramitha, S. 2010. Analisis Kualitas Air Sungai Aloo, Sidoarjo Berdasarkan Keanekaragaman dan Komposisi Fitoplankton. Surabaya: Institut Teknologi Sepuluh Nopember.

[20] Priyambada, I, B, Oktiawan, W, Suprapto,R,P,E, 2008, Analisa Pengaruh Perbedaan Fungsi Tata Guna Lahan terhadap Beban Cemaran BOD Sungai (Studi Kasus Sungai Serayu Jawa Tengah), Jurnal Presipitasi, Vol. 5, No. 2, pp 55-62, http://isjd.pdii.lipi.go.id/admin/jurnal/52085562.pdf

[21] Sachlan. M. 1980. Planktonologi. Institut Pertanian Bogor. Bogor

[22] Sastrawijaya,T.A. 2000. Pencemaran Lingkungan. Rineka Cipta. Jakarta

[23] Subekti I., 2009. Buku Ajar Penyakit Dalam: Neuropati Diabetik, Jilid III, Edisi 4, Jakarta: FK UI pp. 1948

[24] Suriawiria, Unus. 2003. *Air dalam Kehidupan dan Lingkungan yang Sehat*. Penerbit Alumni. Bandung.

[25] Tafangenyasha, C. and T. Dzinomwa. 2005. Land-use Impacts on River Water Quality in Lowveld Sand River Systems in South-East Zimbabwe. Land Use and Water Resources Research 5 **:** 3.1-3.10. http://www.luwrr.com

[26] Wediawati, W. 2001.Indikator Biologi sebagai Kontrol Pencemaran Lingkungan. Majalah Air Minum. Jakarta: Tirta Dharma.

[27] Wilhm, F.F. (1975). *Biological Indicator Pollution In* B.A. Whitoon, (Ed.) River Ecology. Blackwell Scientific Publ. Oxford, England. 375-402 hal.

[28] Wiwoho. 2005. Model Identifikasi Daya Tampung Beban Cemaran Sungai Dengan Qual Study Kasus Sungai Babon. Universitas Diponegoro. Semarang.